Evaluation of Commercial GaN HEMTs for Pulsed Power Applications

F. Fornetti, K.A. Morris, M.A. Beach

Centre for Communications Research, University of Bristol, UK

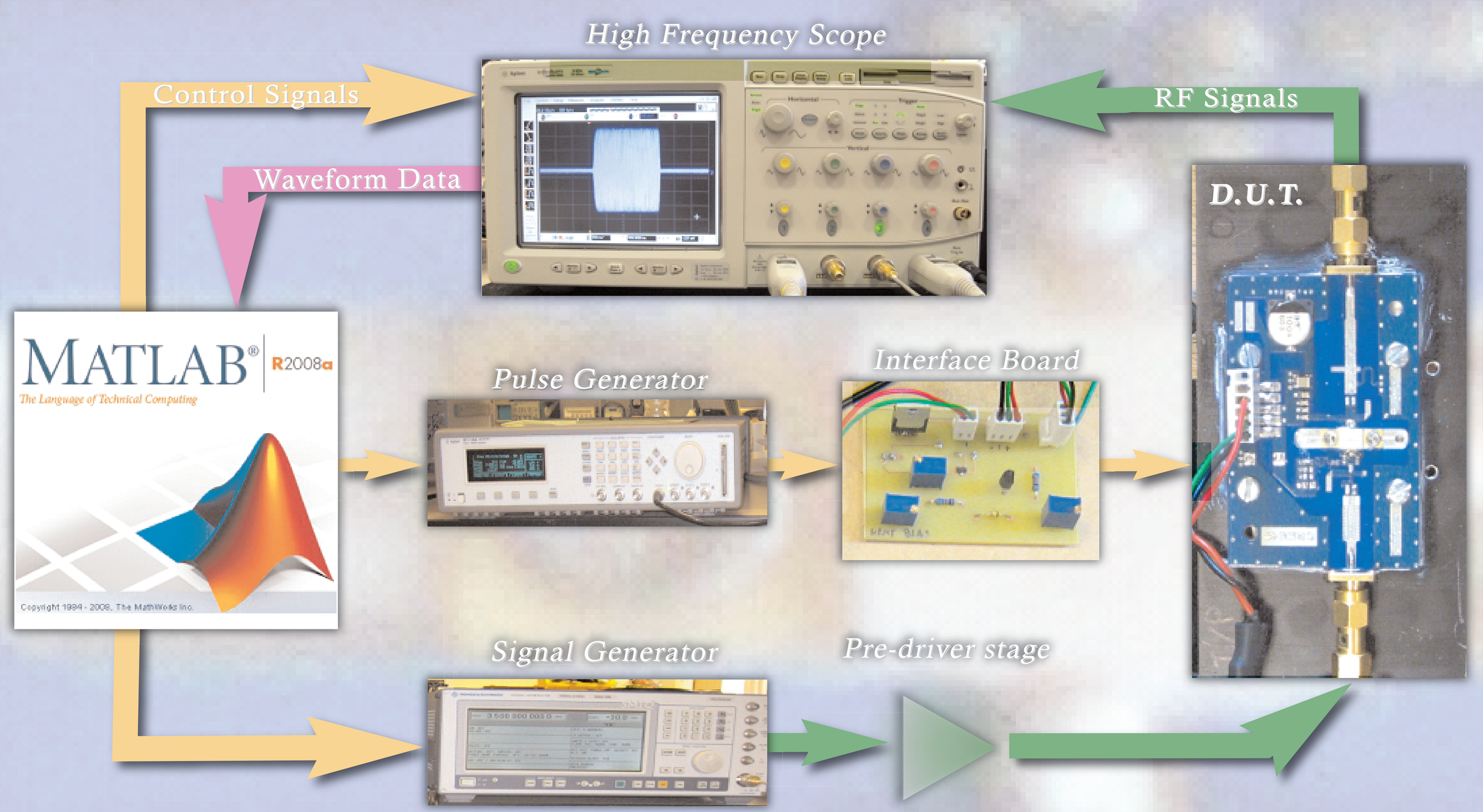
Introduction

The present study investigates the behaviour and performance of commercially available GaN HEMTs when used for the amplification of pulsed waveforms.
GaN technology is not as well understood and established as its GaAs counterpart and a number of studies have reported potential problems, namely:

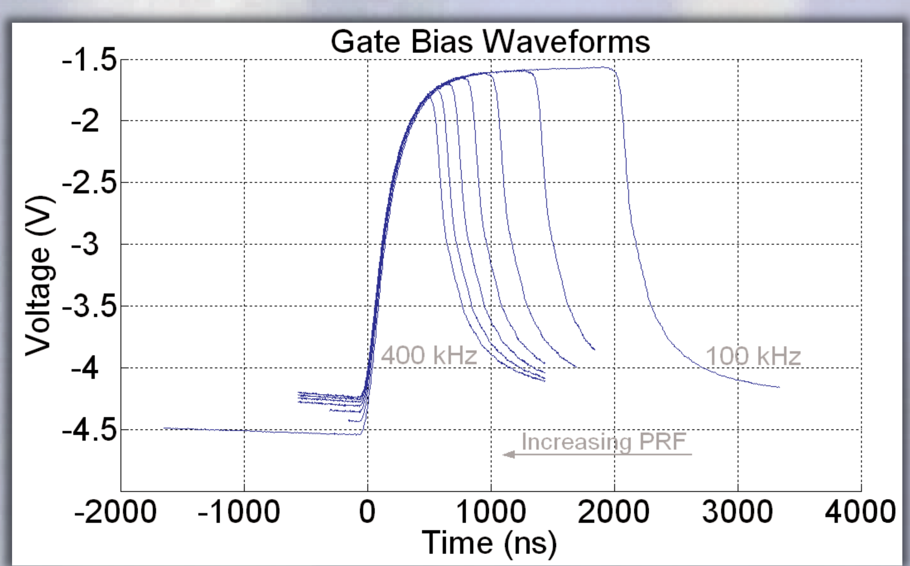
- *Current reduction due to surface states & buffer traps*
- *Virtual gate formation*
- *Gate and drain lag transients*
- *Non-linearities in the source resistance*

These effects could potentially be exacerbated by operating the device in pulsed mode and the experiments conducted aimed to study such fenomena and assess the suitability of commercial GaN HEMTs to pulsed RF applications such as Radar.
The frequency at which the study was conducted was 3.5GHz

Test Setup



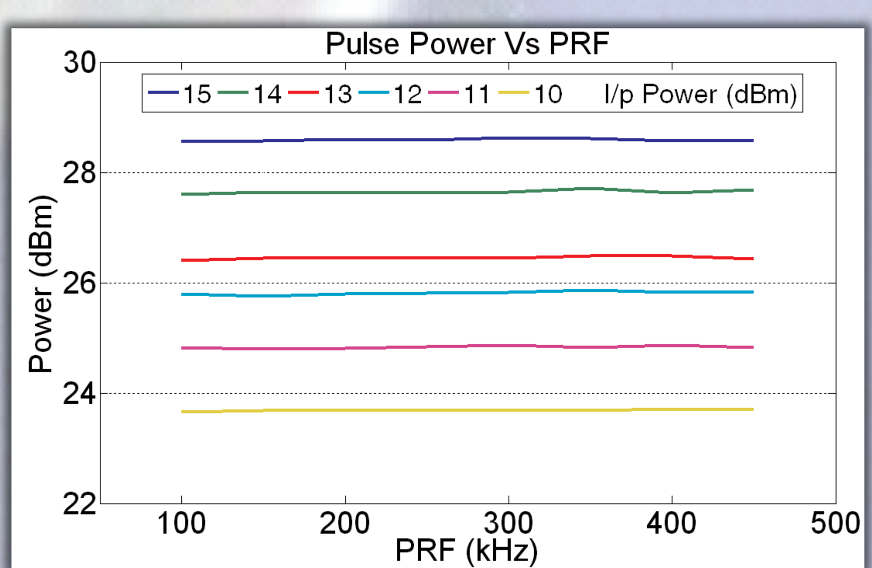
MatLab was used to control the instruments through GPIB and LAN interfaces and also for data acquisition and processing. The pulsed RF was generated by a purpose built interface board which safely turned the transitor fully on and fully off to ensure that full transients would be undergone by the device.



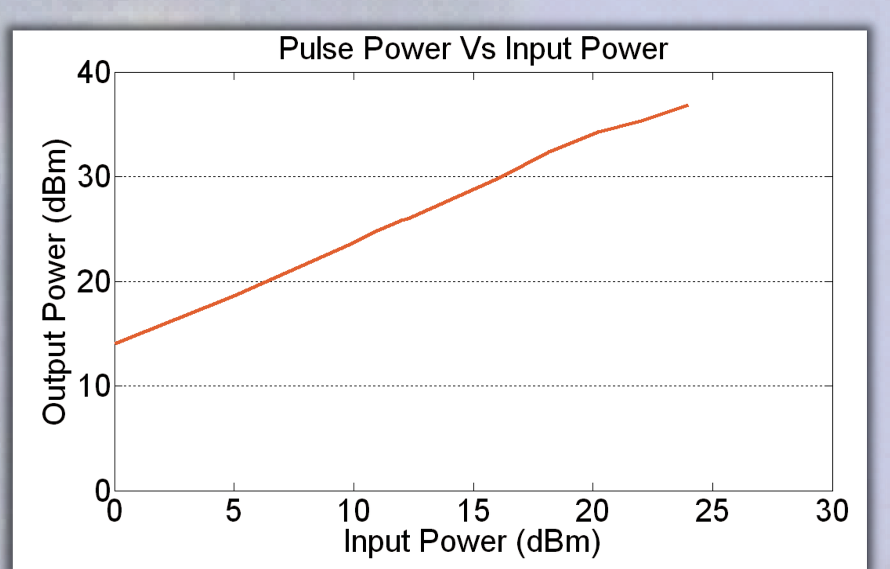
The board was also used to transform the TTL voltage levels generated by the Agilent 81110A into the bias levels required to switch the transistor on and off.

Results

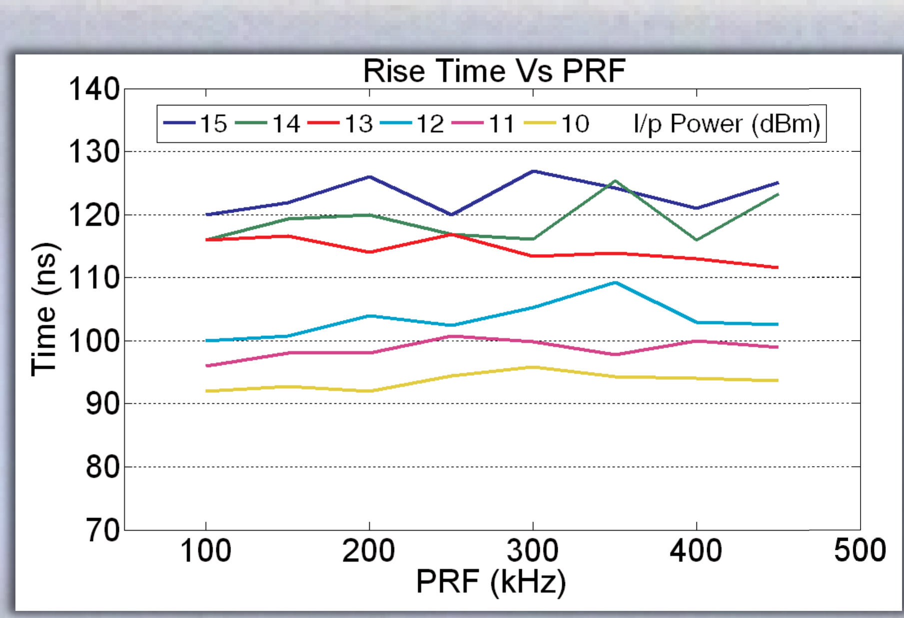
In this section we present the changes in pulse power, rise times and fall times at different input powers as the PRF is increased. Transients on output waveforms are also presented and analysed.



The pulse power was found to remain largely constant across the PRF range.
This would suggest that there is no current reduction due to trapping effects or self heating at the power levels used.

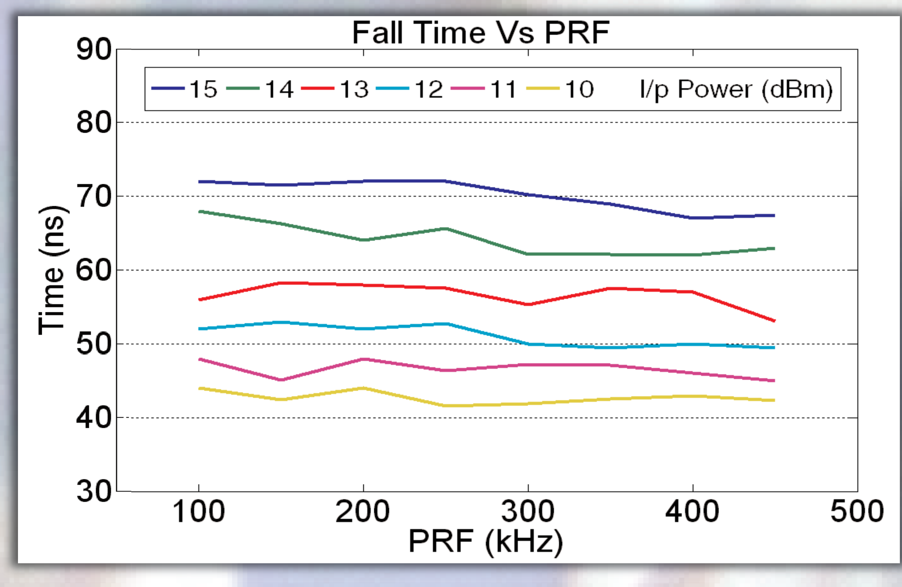


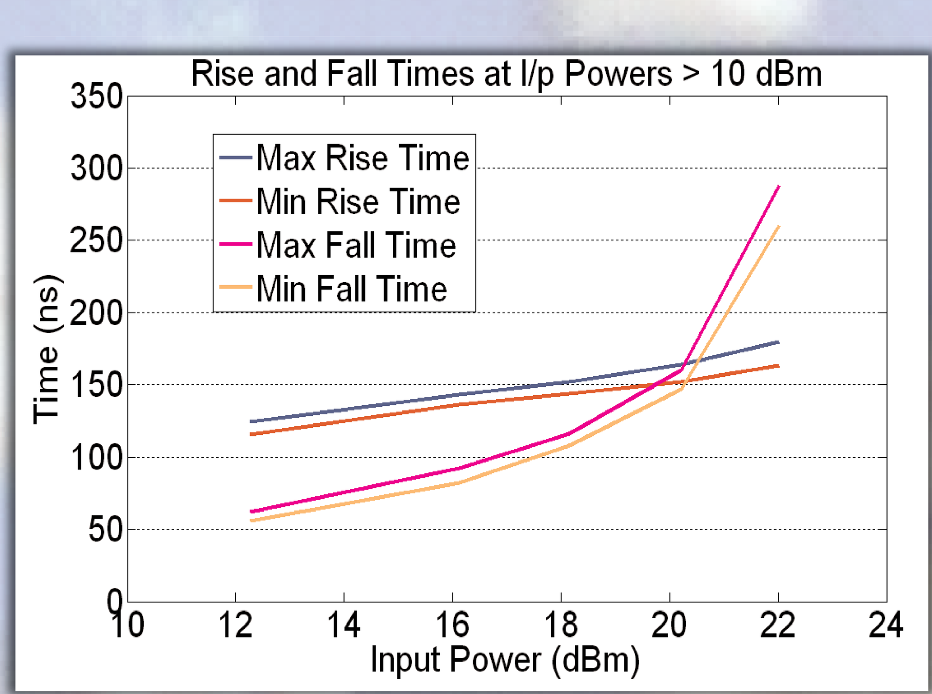
It is apparent that the relationship between the pulse output power and the input power is a linear one albeit some slight variations as the transistor approaches saturation.



Rise and fall times of the RF pulses do increase as the input power is increased.
This is likely to be due to a greater capacitive load determined by higher RF voltages being present.
The maximum variations observed on the rise and fall times were 10 and 8 ns respectively.

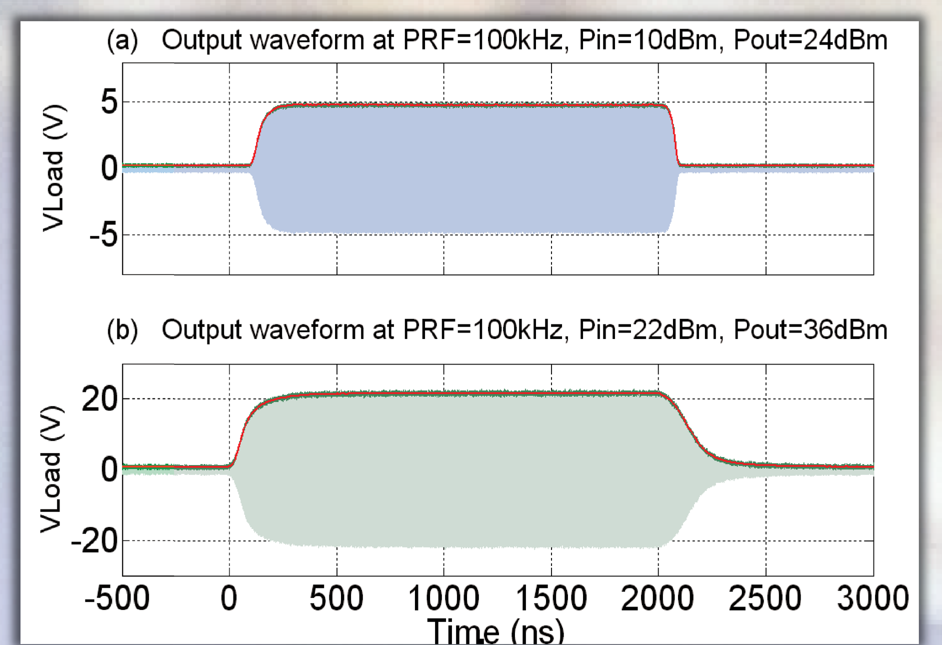
The accuracy of such figures was however affected by the difference in the number of sample points available at different PRFs and by the envelope averaging preformed during data analysis.
The rise and fall times may therefore be considered largely constant across the PRF range for a given power level.





At input powers higher than 22dBm, corresponding to output powers greater than 36dBm, the fall time was seen to increase significantly in an exponential fashion as can be seen in the graph.
In the time domain this was seen to be due to an additional transient on the pulse falling edge at transistor turn-off.

At higher power levels the rise time does not change significantly. The Fall time however suffers a considerable increase due to the presence of an exponential decay on the falling edge.
This demonstrates that the device output capacitance plays a much more significant role when operating near the 1dB compression point of the amplifier.



Conclusions

In this study the suitability of commercially available GaN samples to pulsed operation has been demonstrated. The devices presented a consistent and reproducible performance at specific power levels across a broad range of Pulse Repetition Frequencies (PRFs). These devices could find application in S-band radars which utilise much lower PRFs than those analysed in this study.
The reason for pushing the devices to higher PRFs was to analyse the response that their structure would have to repetition frequencies which are used at higher RF frequencies.
Seeing that higher frequency devices will maintain some commonalities with their lower frequency counterparts, this gives some degree of confidence that future devices could be utilised for pulsed RF applications which operate in higher frequency bands.
Further investigations are needed to gain a better understanding of the effects that operating the devices near their compression point will have on the pulse shape.

Future Work

Future work will focus on repeating the experiments presented in this paper at much higher power levels and on devices with higher power ratings.
Bare die HEMTs will also be subjected to similar tests at frequencies ranging from 6 to 10 GHz.
Additional tests will also be performed to study the spectral content of pulsed waveforms amplified with GaN devices.

Acknowledgements

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